

# KA-BAND ANTENNA DEVELOPMENT

**MIKE THORBURN**


One of the thrusts of the DSN Technology Program is the use of Ka-band (32 GHz) for deep space communication. Compared to our current X-band (8.4 GHz), Ka-band theoretically offers as much as a 12-dB improvement in link performance. Two of the issues that must be solved in order to realize this gain are antenna efficiency and pointing. Because of the smaller wavelength, small imperfections in the surface of the antenna cause larger degradations at Ka-band than at lower frequencies, and because of smaller beam divergence, small pointing errors will have a larger effect.

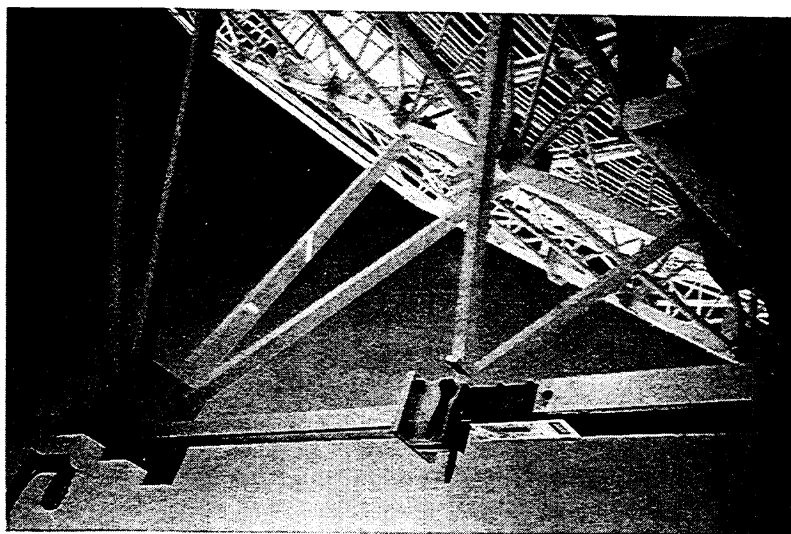
Recently, we have measured significant improvements in antenna efficiency and antenna pointing at the research station (DSS 13) and at the new Ka-band

station (DSS 24). These improvements result, in part, from technology developments in the Antenna Systems work area of the DSN Advanced Technology Program, and the viability of Ka-band for use in future JPL flight projects depends on the successful completion of these efforts.

Two contributors to imperfections in the surface of the antenna at DSS 13 were decreased during fiscal year 1994. First, we used the JPL microwave holography system, originally devised in our program and since developed by DSN Engineering, to reset the antenna panels with great precision, providing improvement at every elevation angle. Then we attacked the problem of antenna sag due to gravity, which varies with antenna elevation. We designed, built, and installed the CAMMATIC gravity compensation system, consisting of two large actuators to compensate for this variation of antenna sag, and thus increased aperture efficiency as a function of elevation angle.

In addition to these developments, fundamental work in the antenna structural design has enabled us to recommend improvements and thereby reduce this gravity induced sag in the forthcoming antennas in the DSN. The new beam waveguide antenna (BWG) at DSS 24 was completed after we analyzed the lessons learned from DSS 13 and incorporated improvements into the DSS 24 structural design. Measurements indicate that for Ka-band, the performance of DSS 24 is significantly better than that of DSS 13.

Additionally, a BWG Conscan Mirror at DSS 13 was demonstrated to provide superior pointing performance at Ka-band. 



**THE CAMMATIC GRAVITY COMPENSATION SYSTEM REDUCES GRAVITY INDUCED SAG.**

# LINEAR ION TRAP FREQUENCY STANDARD

**JOHN DICK**

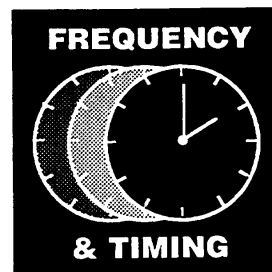
The DSN stations need very stable frequency standards. Hydrogen masers currently serve this purpose. The DSN Technology Program has developed a new standard called the Linear Ion Trap Frequency Standard (LITS). Recent tests of the LITS show the highest stability yet measured for any frequency standard for measuring times from a day to about a week. This technology makes possible a simpler ultra-high stability frequency standard than that available with the hydrogen masers currently installed in the DSN. Use of the new standard will provide improved performance as well as reduced maintenance for NASA deep space communications, navigation, and radio science.

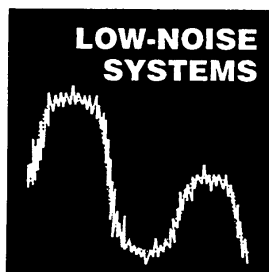
Two LITS standards have been operating for some months now, and a substantial body of long-term test data has accumulated. The data describe a new region of stability for measuring times of  $1E5$  to  $1E6$  seconds which is substantially better than  $1E-15$ , with values typically ranging from 6 to  $7E-16$ . This capability will help to make feasible

radio science such as the gravitational-wave search planned for the Cassini Ka-band investigation.

Two additional LITS frequency standards are currently under construction. The first of these is a unit being engineered for DSN implementation and will serve as a basis for further DSN units. The second is a nearly completed unit under contract to the U.S. Naval Observatory (USNO), which will participate in the conglomerate of standards that make up our nation's timekeeping capability. (In this capacity, such a unit may be worth 100 to 1000 of the more conventional Cesium standards that typically contribute to this timekeeping.)

A smaller version of the LITS, dubbed LITE by our work unit leaders, is presently under development with a goal of increased stability in a substantially smaller package. First tests of this newer standard are expected in the 2nd quarter of this fiscal year. A decision is expected by the end of FY95 as to whether the improved physics package of LITE can be incorporated into the first DSN units. 🦊





# CRYOGENIC WAFER PROBE STATION

JAMES SHELL

**Perhaps the biggest benefit is that non-destructive measurements can be performed on wafers that have just been completed without having to thin them, dice out the devices, and bond them into test fixtures.**

The ground receiving station component of a deep space communications link requires a low-noise preamplifier mounted at the focal point of a large radio telescope antenna. The purpose of the low-noise preamplifier is to provide the maximum system sensitivity (lowest noise temperature) thus providing the electronics downstream with the maximum signal-to-noise ratio (SNR). Historically, the DSN has relied on ruby masers cooled to 4.5 K in closed cycle helium refrigerators to provide this function.

The development of new semiconductor devices (High Electron Mobility Transistors (HEMTs)), based on selectively doped GaAs-based heterostructures, promises to provide amplifiers with maser-like noise temperatures at a fraction of the cost. Many thousands of transistors can be grown on a single semiconducting wafer, thus reducing the unit cost. Furthermore, the HEMT-based amplifiers can operate at a higher physical temperature (typically, 15 K) thus reducing the refrigerator costs. These amplifiers also hold the promise of wider bandwidth, greater power handling capability, and greater gain stability.

One of the key elements to achieving state-of-the-art HEMT devices is the development of a cryogenic wafer probe station. The DSN Advanced Technology Program is completing such a station, one of few currently in use.

Wafer probing at room temperature is fairly well developed, and there are several major benefits. Perhaps the biggest benefit is that nondestructive measurements can be performed on wafers that have just been completed without having to thin them, dice out the devices, and bond them into test fixtures. Wafer probing also preserves the positional information of the device on the

wafer. Surveys can be conducted across the wafer to yield the spread in device RF parameters. These data are particularly useful for improving wafer processing. Furthermore, obtaining data at the device level eliminates the additional step of de-embedding the data if a test fixture is used.

These same advantages exist for the cryogenic characterization of the devices. However, the measurements at cryogenic temperatures are considerably more complex. The requirement of a good vacuum environment, low temperatures, and vibration isolation from the closed cycle helium refrigerator drive unit and vacuum pumps necessitates some development. A vector network analyzer and on-wafer RF calibration standards are also crucial.

Our recently completed cryogenic wafer probe station will be used in optimizing performance of HEMTs for use as cryogenic amplifiers in the DSN. The station's use is fundamental in optimizing the HEMT performance. Initially, the focus will be towards obtaining accurate RF scattering parameters.

The probe station will be used in achieving the best noise performance. The input device must be noise matched, presenting the proper impedance match to the device. The minimum device noise temperature is also of fundamental interest. The measurement of on-wafer noise parameters is a difficult task and is a topic of current research.

Another use of the probe station is in the area of RFI protection. It can be used to accurately measure the insertion loss and return loss of microstrip filters that might be incorporated into the amplifier. It may also be possible in the future to perform gain compression and intermodulation distortion measurements on-wafer. 